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Opacity of photoionization plasmas generated by laser-produced blackbody radiator

レーザープラズマ黒体輻射光源で生成した光電離プラズマの吸収分光特性

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We measured opacity of non-LTE photoionized silicon plasmas generated by a laser-produced blackbody radiator having two roles as for a radiation source and a backlight source. We used the transmission grating spectrometer with an observation range from 1.5 to 8 nm. We analyzed the experimental result with theoretically predicted opacity for non-LTE photoioinized silicon plasmas with atomic kinetic codes, FLYCHK and PrismSPECT. A large discrepancy was found between the observation and the prediction that is attributed to contamination on the surface of silicon specimen.

1. Introduction

Photoionized plasmas are observed around compact objects such as black holes [1]. The structure and evolution of compact objects are indirectly studied in a remote distance by observing x-ray continuum from heated accretion discs and x-ray fluorescence from the photoionized plasma of the stellar wind in the binary systems. X-ray spectroscopy is an important tool for diagnosing conditions in photoionized plasmas [2]. To derive physical properties from the observations, we must simulate physical properties by radiation-hydrodynamics codes including complex physical processes to simulate x-ray spectra by atomic kinetic codes. However very few photoionized plasma experiments have been performed to benchmark the astrophysical model for the photoionized regime[3]. Laboratory experiments are essential in this field in order to improve physics modeling in the code.

2. Experimental methods

GEKKO-XII at ILE Osaka was used to create an intense x-ray flash Plankian spectrum, which mimick x-ray continuum from the accretion disks [4]. At the same time, cold and low-density silicon plasma was generated by a Nd:YAG laser pulse near the implosion core. In the way, x-ray from the implosion core excited and photoionized the silicon plasma.

We measured absorption spectra of photoionized silicon plasma. The implosion core was also utilized as for a backlight source. We show the experiment scheme in Fig.1.

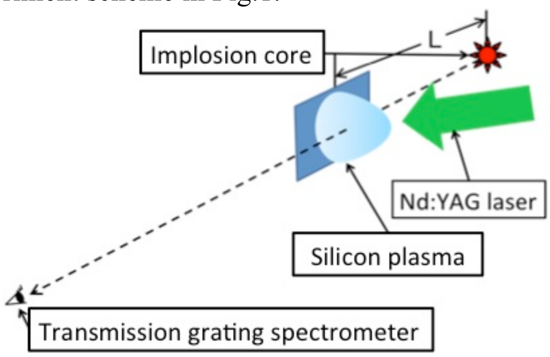

Fig.1. The experiment scheme

Experimental conditions for implosion cores, silicon plasmas and transmission grating spectrometer are shown as Table.1.

In order to control the intensity of x-ray on the Si plasma, the distance *L* from implosion core to silicon plasma was changed from 1.2 to 6 mm.

3. Experiment results

Observed transmission of photoionized silicon plasma is shown in Fig.2.

Ionization parameter ξ is defined as

$$\xi = I_x / n_e L^2, \quad (1)$$

here I_x is x-ray luminous [erg/s], n_e is electron density [cm^{-3}], and L is the distance from the blackbody radiator to the silicon plasma [cm] [5].

Table1. Parameters of implosion core, silicon plasma and transmission grating spectrometer

Implosion core	
Color temperature	420 ± 10 eV
X-ray pulse duration	160 ± 40 ps (FWHM)
Silicon plasma	
Average electron temperature (before photoionization)	27.5 ± 1.5 eV
Average electron density (before photoionization)	$(0.75 \pm 0.25) \times 10^{20}$ cm^{-3}
Size of plasma	500 μm
Distance from implosion core L	1.2, 3, 6 mm
Transmission Grating Spectrometer	
Range of observed wavelength	1.5 ~ 8 nm
Spectle resolution $\lambda / \delta\lambda$	13.3 (FWHM)

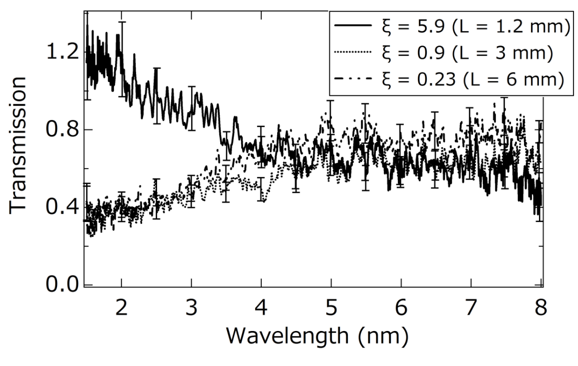

Fig.2. Absorption spectra for the silicon plasma

A large difference in the transmission curves is seen between the case of ξ = 5.9 and these of ξ = 0.9 and 2.3.

In the presentation, we will discuss on the reason of the difference together with calculations by non-LTE collisional radiative model treated in FLYCHK [6] and PrismSPECT [7].

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